PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Improvements in or relating to Bonding of Materials

We, OMEGA LABORATORIES LIMITED, a British Company, of 72—78, Fleet Street, London, E.C.4., do hereby declare the invention, for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to bonding of materials (e.g. textile or other materials partly or wholly composed of thermoplastic material) and more particularly to bonding by ultrasonic energy.

This invention is particularly applicable to bonding in the form of "stitches", i.e. bonding in which the bonding consists of a plurality of individual bonds which may be separated from each other longitudinally or may make up a seam by overlapping the ends of the individual bonds. It is to be understood that the term "stitch" is used in this context throughout this specification and claims and is not intended to limit the length of the individual bonds.

The invention seeks to provide a method and apparatus in which the power used to provide bonds can be so controlled that whatever the bonding or stitching speed used, the correct bonding power is applied to the material to be bonded within practical limits and variations in speed will not produce any material variation in the bonding (strength of bond, etc).

According to one aspect of the invention there is provided a method of bonding together materials at least one of which is wholly or partly synthetic which method comprises feeding the materials to be bonded through a bonding head in accordance with the feed rate so as to provide the same amount of power for each individual "stitch".

According to a second aspect of the invention there is provided an apparatus for bonding together materials at least one of which is wholly or partly synthetic, which apparatus comprises a bonding head, a generator for supplying ultrasonic energy to the bonding head for bonding the materials, means for feeding the materials to be bonded through the bonding head, and controlling means for varying the energy supplied to the bonding head in correlation to the feed rate so as to provide the same amount of power for each individual "stitch".

The invention will now be described in greater detail by way of example with reference to the accompanying drawings, in which:—

Figure 1 is a diagram showing the general principles of the operation of an apparatus in accordance with the invention;

Figure 2 is a block diagram showing one form of supply to the bonding head of the apparatus of Figure 1;

Figure 3 is a block diagram showing an alternative form of supply;

Figure 4 is a sectional end view of a practical example of the apparatus as shown in Figure 1; and

Figure 5 is a sectional view on the line V—V of Figure 4 with certain parts not shown.

Referring now to Figure 1 the bonding apparatus comprises an ultrasonic generator 1 which supplies ultrasonic electrical energy to a magnetostrictive transducer 2. The generator is of the usual form and includes an oscillator and amplifier. The transducer 2 converts the electrical energy into mechanical vibrations which are transmitted to a velocity transformer 3 forming a probe. The probe 3 forms with an anvil or arbor 4 the bonding head of the apparatus.

The anvil or arbor 4 is mounted for movement towards and away from the probe 3 and

is urged towards the probe 3 by a spring 5 when that spring is in compression.

The material to be stitched is indicated at 6 and is fed to the left (in the drawing) by a conventional transport mechanism of the type used in standard needle sewing machines indicated at 7. The transport mechanism 7 is driven by an electric motor 8 through suitable linkage 9 (indicated in the drawing as an eccentric and rod mechanism), the speed of the motor being controlled in the normal way through a variable resistance 10 operated by a foot pedal 11.

The motor 8 also controls the compression of the spring 5 through a linkage 12 (inidcated in the drawing as an eccentric and rod mechanism) and the linkages 9 and 12 are so arranged that during the time when the material 6 is stationary (i.e. during the return stroke of the transport mechanism 7), the spring 5 is compressed to urge the anvil or arbor 4 against the probe 3.

Switching or triggering of the generator 1 to supply energy to the probe 3 only when the probe and anvil or arbor are in their spring biased condition is controlled by a switch 14 which operates in response to movement of the anvil or arbor 4. This switch 14 controls operation of a control and timing device 15 which controls the energy supply to the probe 3 by controlling the generator 1 and providing in certain circumstances a bias for the transducer by way of line 16.

The operation of the apparatus will now be described.

With the apparatus in the condition shown, the end of the material is fed between the probe 3 and anvil 4 and the pedal 11 is depressed to start the apparatus.

The transport mechanism 7 moves forward taking the material with it so as to position the material fully between the probe 3 and anvil 4 whereupon the mechanism 7 starts to return for its next stroke. As it does so, the spring 5 is compressed by linkage 12 forcing the anvil 4 against the probe 3. Motion of the linkage 9 closes the switch 14 and operates the device 15 which allows a certain amount of energy to be fed to the probe 3. After the required energy has been transmitted to the probe, the device 15 cuts off the supply on which the bonding of the first stitch is finished.

As the mechanism 7 reaches the end of the return stroke, the compression in the spring 5 is released and allows the anvil 4 to be pushed away from the probe 3 due to the resilience of the material 6 being bonded. This motion of the mechanism 7 and the linkage 9 opens the switch 14 ready for the next operation.

After the mechanism 7 has reached the end of its return stroke it again moves forward carrying the material 6 with it, leaving it at the end of the forward stroke positioned for the next bonding of a stitch. The process is then repeated.

The control and timing device 15 has the function of metering the energy supply. This can be done in many ways to achieve the same effect, for example it can act purely as a timing device and trigger the oscillator for a certain length of time, the generator power remaining constant. Alternatively the time of the operation of the oscillator could vary depending on the timing of the stitching and the power could be varied to match. Also it can operate to bias back the transducer and thus control the power and cut-off of the ultrasonic vibrations.

In this sort of way, the energy used in the making of each stitch can be kept constant so as to ensure that each stitch has the same bond characteristics, and thus, for any particular materials, the apparatus can be set to give the best bond characteristics irrespective of the speed at which the apparatus is operating or the frequency of the stitches.

The speed of operation of the apparatus is of course controlled by the operator by means of the foot pedal 11 in the usual way.

Figure 2 is a block diagram of the power-supply to the bonding head and includes both the generator 1 and the control unit 15. The apparatus of this block diagram is of standard valve design and includes a continuous sine wave oscillator 20 of ultrasonic frequency feeding a power amplifier 21 by way of a control device 22. (The oscillator 20 and amplifier 21 comprise the generator 1 of Figure 1 and the control device 22 comprises the control unit 15 of Figure 1). The power amplifier 21 feeds the transducer 2 (Figure 1) by way of line 23.

The switch 14 (Figure 1) is connected to the control device 22 by line 24 and the operation of this switch in one direction causes the control device to permit power to reach the transducer 2. This can, for example, be achieved by switching the amplifier 21 as is well known or any other suitable means can be employed. Either closing or opening of the switch 14 can be made to initiate the operation of the control device depending on the desired construction. The control unit 22 will cut off the power automatically after a predetermined time interval and this interval can be set by means of a setting control indicated at 25. The power output of the amplifier 21 is adjustable by a control 26 and this control is carried out in any known manner.

The amplifier block 21 will also supply a D.C. bias for the transducer 2, which bias is necessary for efficient operation.

Figure 3 is an alternative block diagram and shows the required parts of the generator 1 and control unit 15 when transistorised circuits are used. In this case the power supply is provided by an oscillator 30 of continuous sine wave type, the output of which is used

to switch transistors in the final stage of an amplifier unit 31 at ultrasonic frequency. The oscillator 30 feeds the amplifier 31 through a control device 32 which switches the power "on" and "off" in response to the operation of the switch 14 connected thereto by a line 33. This unit has the same function as the unit 22 of Figure 2 and is provided with a setting control 34 for control of the power "on" interval. The amplifier 31 is connected to the transducer by the line 35 and in this case does not supply any D.C. bias.

Since the power in the amplifier is provided solely by switching transistors at ultrasonic frequency, difficulty has been experienced in varying the power to the transducer with transistorised power supplies. To overcome this a separate bias supply 36 is provided connected by line 38 to separate bias coil on the transducer. Thus by controlling this bias supply 36 (setting control 37) the power of the transducer is controlled. Some bias will of course be permanently required for efficient operation of the transducer and it has been found in practice that good results are obtained when maximum bias on the transducer produces maximum power.

It will be understood that in both Figures 2 and 3, the external power supply has not been shown for the sake of clarity.

As can be seen from the foregoing description, the control of the power is so arranged that a predetermined amount of power is applied irrespective of the bonding stroke or "stitch" speed as a predetermined pulse of power is provided at each "stitch". Of course, the power and interval of application should be so arranged that the interval is considerably less than the fastest "stitch" available to the machine.

A practical example of a bonding apparatus suitable for operation in accordance with the invention is shown in Figures 4 and 5. The particular apparatus shown is intended mainly for factory use and for this purpose is built into a table, the top of which is shown at 51. The apparatus has the outward appearance of a "sewing machine" and is provided with a housing 52 mounted on the table top 51 at 53 and provided with a portion 54 housing a reciprocating mechanism to be described.

The ultrasonic supply units are not shown in these Figures because they are purely electronic and have been referred to in Figures 2 and 3.

The mechanical operation of the apparatus is controlled by an electric motor 55 mounted beneath the table top 51 and is controlled by a foot pedal or other suitable control (not shown). Drive from the motor 55 is taken via a drive pulley 56 on the motor shaft 57, which pulley 56 drives a belt 58 which in turn drives a belt 59 by reduction pulley gearing 60. The belt 59 drives a main drive pulley 61 which in turn drives a shaft 62 within the housing 51 running in ball bearings one of which is shown at 63 and carrying a pulley 64 for a toothed belt 65.

The shaft 62 is connected by a universal joint 66 to a shaft 67 which in turn is connected by a universal joint 68 to a shaft 69. The shaft 69 drives a variable eccentric 70 and causes oscillation of a rod 72 in a vertical direction, the bottom end of the rod 72 being provided with an arbor 73 which co-operates with an ultrasonic probe 74.

The arbor 73 is arranged during it downward stroke to press on the probe 74 with a predetermined pressure in order to ensure proper bonding and this pressure is set by a tension spring 75 acting on the eccentric mechanism 70 through a rod 76. The pressure applied by this spring can be varied by moving the eccentric 70 in a housing 78 which supports the spring 75 and for this purpose a knob 79 is provided. A presser foot 80 is provided to co-operate with the reciprocating arbor and the pressure of this foot 80 is regulated by a knob 81 which varies the compression of a spring 82.

The reciprocating mechanism can be lifted away from the work to allow fresh material to be inserted or for the bonded material to be removed. This is achieved by means of a lever 84 which rotates a cam 85 to raise the housing 78, the universal joints 66 and 68 permitting this movement.

The ultrasonic power for bonding is provided by the probe 74 which is in fact the end of a horn on velocity transformer 88. Two velocity transformers are provided to provide increased power to the probe 74, the lowermost transformer 89 being mounted directly on to a transducer 90 in an oil filled casing 91. The transducer is also provided with an outer casing 92 and between the casings 91 and 92 air is circulated by a blower 94 to cool the transducer. The operating coils of the transducer 90 are shown at 96 and these may be a combined bias and power winding or two separate bias and power windings according to the different types of power supply used (see description in connection with Figures 2 and 3).

The feed mechanism for the material to be bonded is shown at 100 and will move the material in the direction of the arrow 101. The feed mechanism consists of a toothed member 102 supported on a member 103 attached at both ends to bell crank levers 104 and 105. These bell crank levers 104 and 105 are operated by two arms 106 and 107 which are caused to reciprocate by a double eccentric arrangement 108 driven by a shaft 109. This linkage will give the member 102 a substantially rectangular movement and will cause it to feed the material in the way commonly applied to "sewing" machines.

The shaft 109 is driven by the toothed belt 65 through pulley 110.

Also provided on the shaft 109 is a cam 112 which operates the moving contact 113 of a switch 114 (corresponding to switch 14 in Figure 1). Thus the switch will be synchronised with the reciprocation of the arbor 73 and the cam 112 is set on the shaft to provide operation of the switch 114 to provide power to the probe 74 when the arbor 73 is in its lowermost position.

The above described apparatus will operate at quite a high speed, for example 400 inches per minute with ten stitches per inch giving a speed of 4000 stitches per minute. Thus with a bonding to transport ratio of 1:1 i.e. where the period of time to transport the material is equal to the time during which it is being bonded, the maximum bonding time will be approximately 7.5 milliseconds allowing a maximum pulse of energy of 7.5 milliseconds with a 7.5 millisecond gap between pulses.

If a speed of 400 inches per minute is taken to be the maximum speed of the apparatus it is feasible to use this bonding duration of 7.5 milliseconds for all speeds of the machine. Thus while the transport time to the time during which the material remains stationary will remain 1:1 the ratios of transport time to bonding time will vary in order to maintain constant energy pulses of 7.5 milliseconds. In this way, while the duration of the pulses remain constant, the gap between pulses will vary.

The power of the energy in the pulses will of course vary for different materials and would of course be set before stitching begins. In practice, it might well be desirable to vary the bonding time as well as the power depending on the materials used.

The apparatus above described could be used to provide separate "stitches" or overlapping "stitches" could form a seam bond. The arbor and probe could be of sufficient size to make "bar stitches" and special arbor such as a wheel could be employed for special effects.

The switch 14 or 114 could equally well be associated with the reciprocating mechanism instead of the feed mechanism as shown.

WHAT WE CLAIM IS:—

1. A method of bonding together materials at least one of which is wholly or partly thermoplastic which method comprises feeding the materials to be bonded through a bonding head, supplying ultrasonic power to the bonding head, and controlling the supply of ultrasonic power to the bonding head in accordance with the feeding rate so as to provide the same amount of power for each individual "stitch".

2. A method of bonding as claimed in claim 1, wherein the material to be bonded is fed intermittently past the bonding head and the supply of ultrasonic power is controlled to provide power only when the material is stationary.

3. A method of bonding as claimed in claim 2, wherein the method also includes causing the parts of the bonding head on each side of the materials to be bonded to be pressed together when the material is stationary.

4. A method of bonding as claimed in any one of the preceding claims, wherein the control of the ultrasonic supply is carried out by varying the intermittent supply to the bonding heads.

5. An apparatus for bonding together materials at least one of which is wholly or partly thermoplastic, which apparatus comprises a bonding head, a generator for supplying ultrasonic energy to the bonding head for bonding the materials, means for feeding the materials to be bonded through the bonding head, and controlling means for varying the energy supplied to the bonding head in correlation to the feed rate so as to provide the same amount of power for each individual "stitch".

6. An apparatus as claimed in claim 5, wherein the bonding head comprises an ultrasonic probe and a reciprocating arbor cooperating with the probe, means being provided for supplying energy to the probe only when the arbor is in its bonding position adjacent the probe.

7. An apparatus as claimed in claim 6 wherein the means for varying the energy supplied to the bonding head comprises means for supplying power to the probe for a predetermined interval for each reciprocation of the arbor, thus the bonding power for each bond will be the same irrespective of the speed of bonding.

8. An apparatus as claimed in claim 7, wherein a switch is provided which operates in synchronisation with the movement of the arbor, operation of the switch initiating supply of power to the probe.

9. An apparatus as claimed in claim 8, wherein the feed mechanism for the material to be bonded is synchronised with the reciprocation of the arbor so that no movement of the material takes place when the arbor is in its bonding position and the switch is operated by the drive for the feed mechanism.

10. A method of bonding together materials at least one of which is wholly or partly thermoplastic which method is substantially as described with reference to the accompanying drawings.

11. An apparatus for bonding together materials at least one of which is wholly or

partly thermoplastic which apparatus is substantially as described with reference to the accompanying drawings.

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Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.

FIG.1

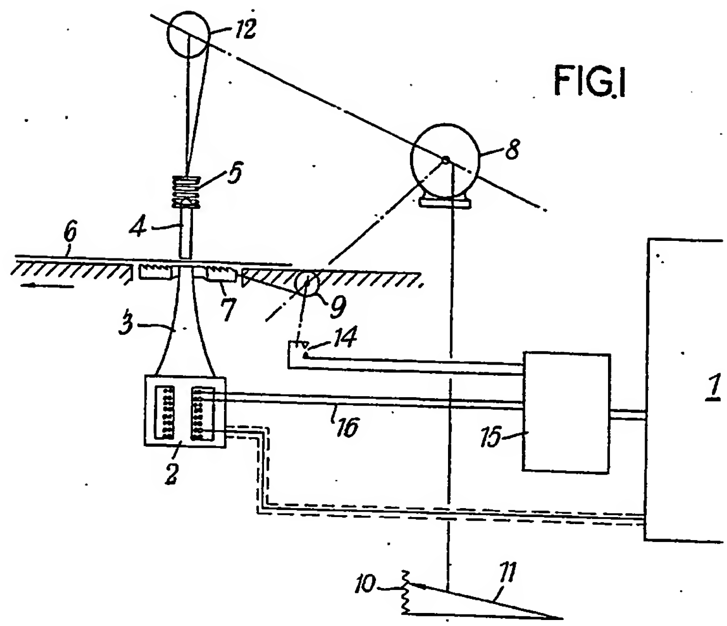


FIG.2

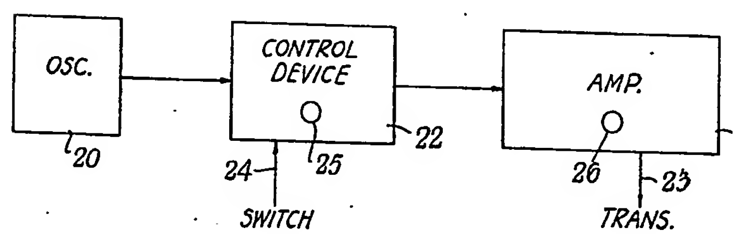
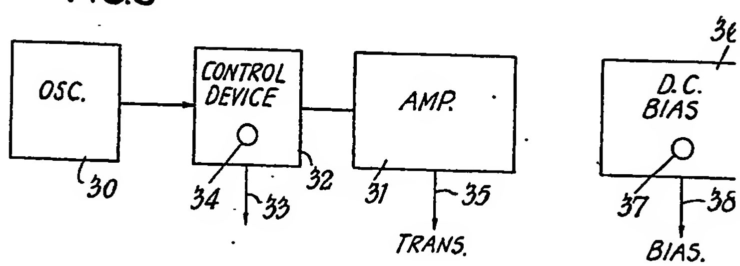


FIG.3



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3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheets 1 & 2

FIG.I

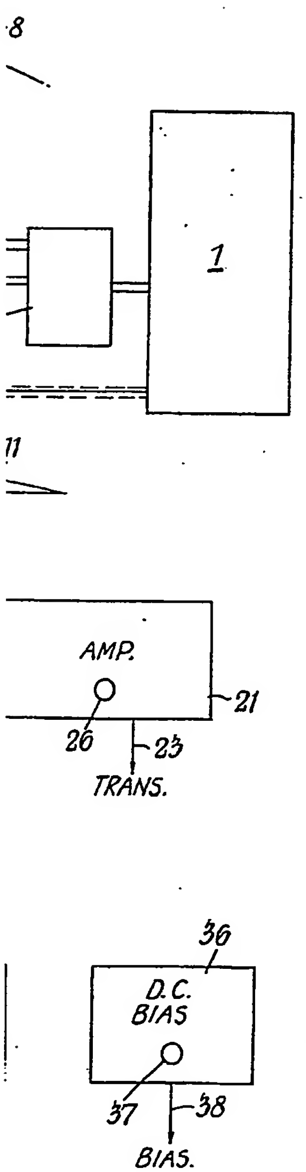
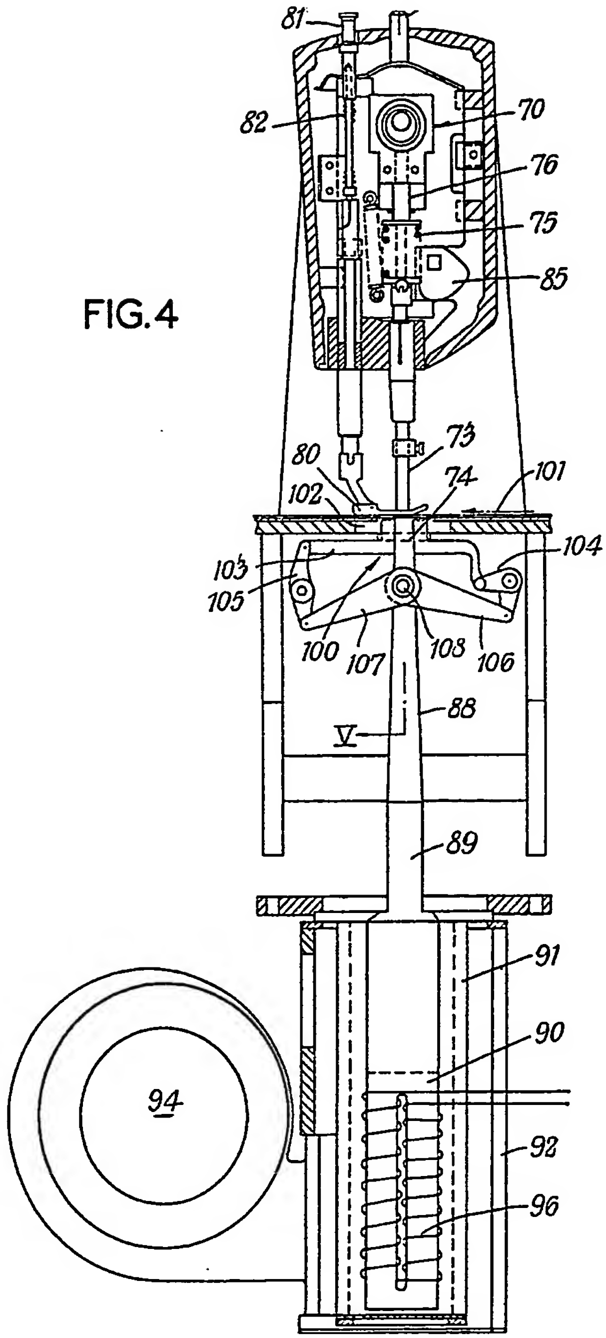


FIG.4



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Sheets 1 & 2

FIG.1

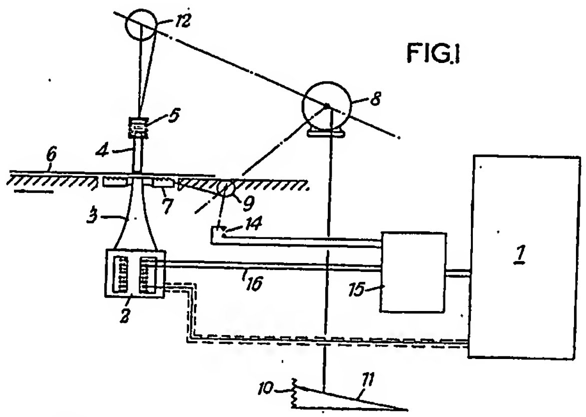
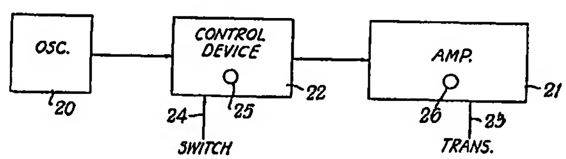


FIG.2



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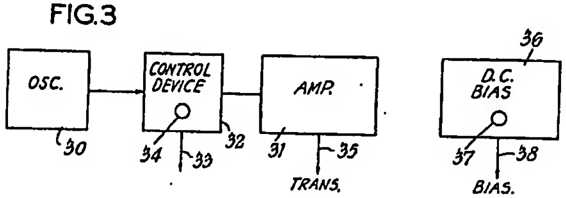
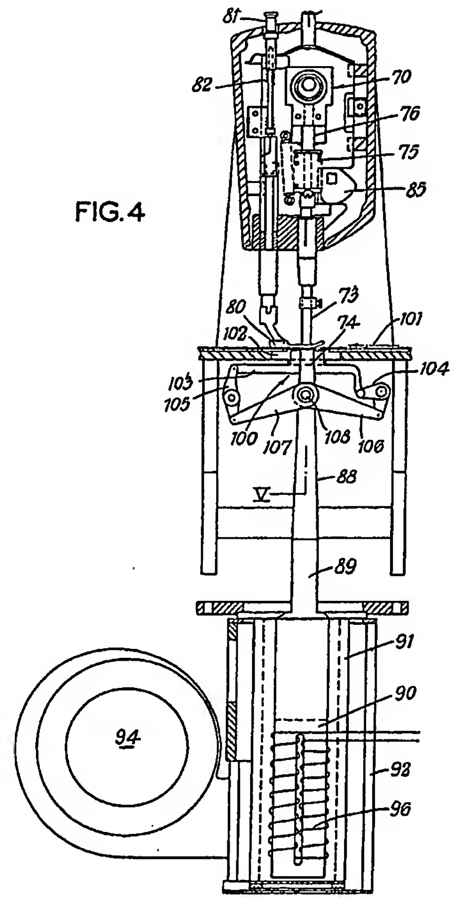


FIG.4



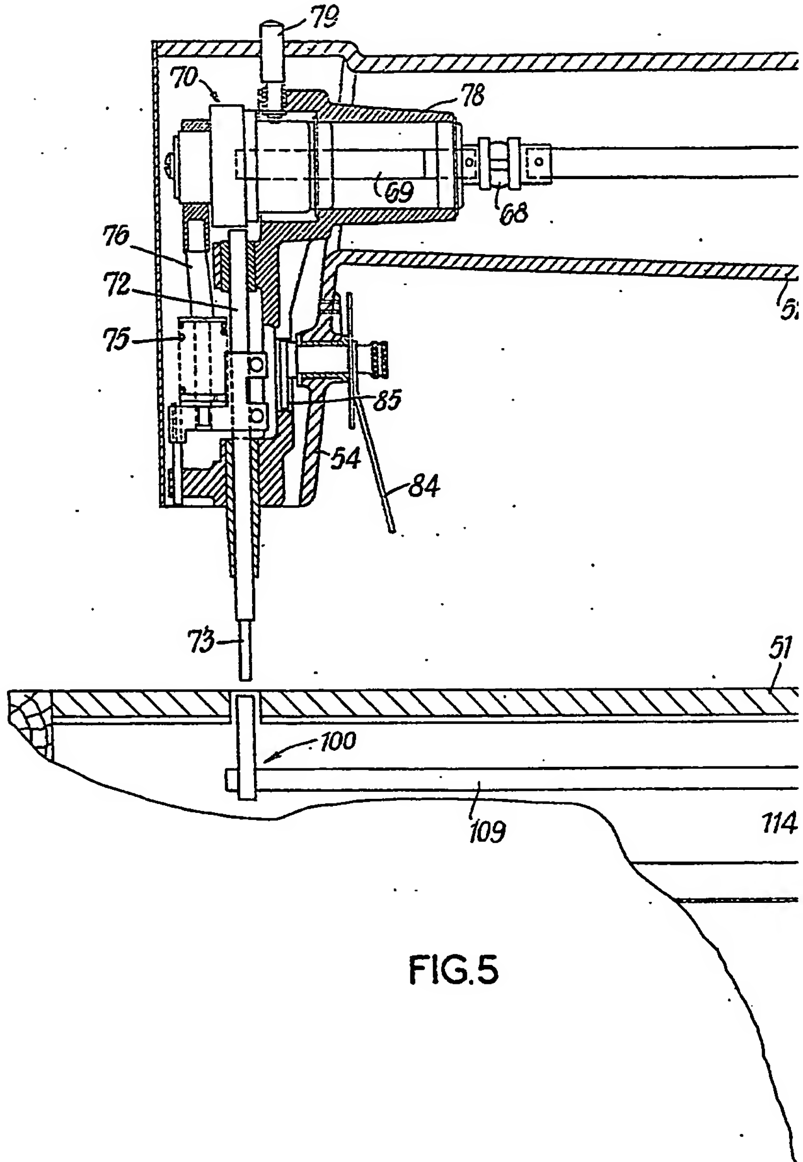


FIG.5

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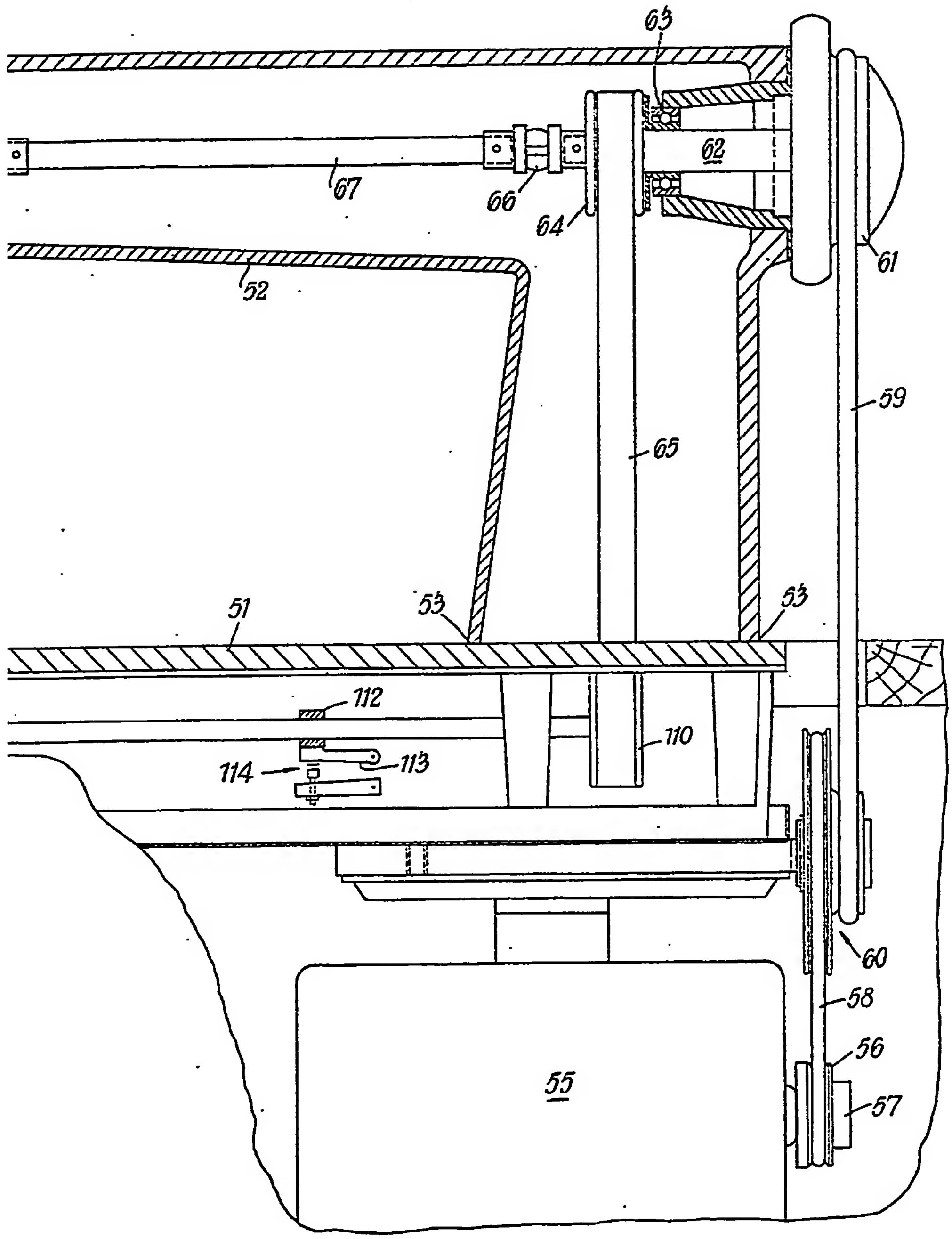
Sheet 3



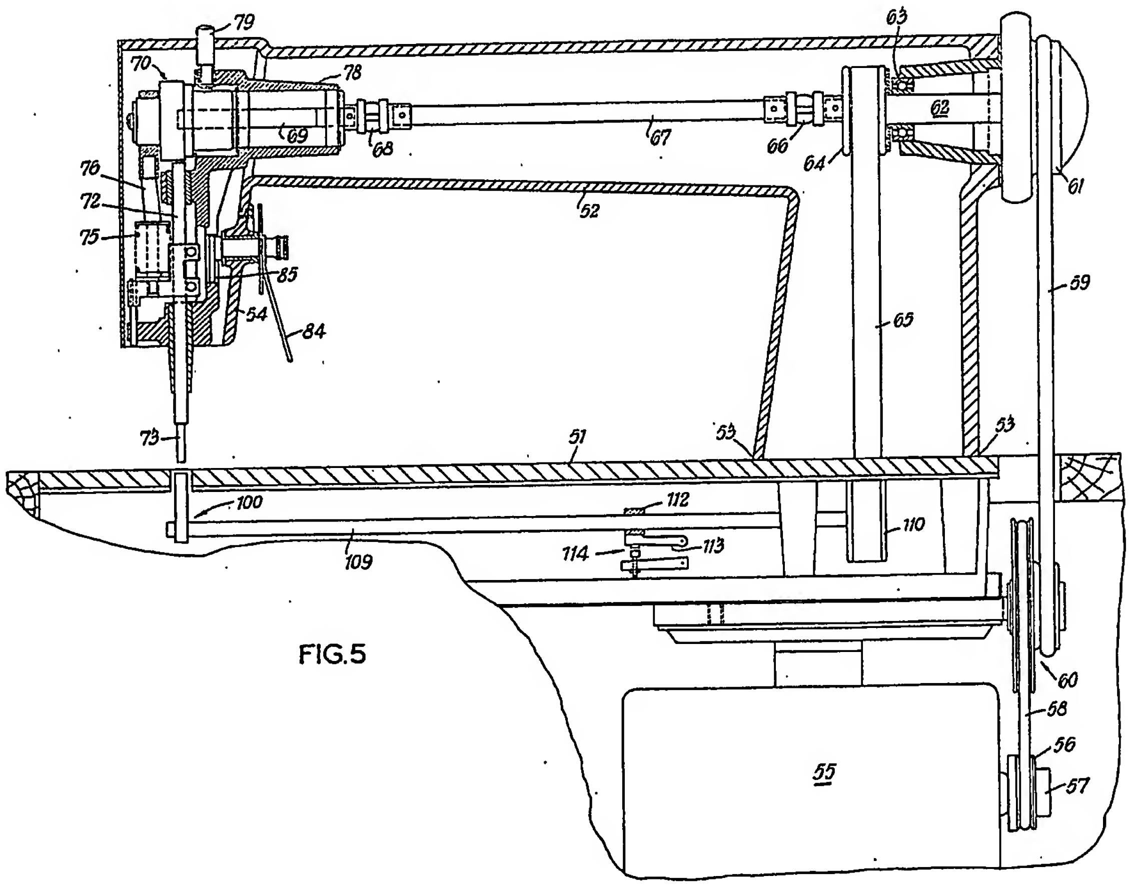

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FIG.5